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Species Composition and Structure of Oak-Saw Palmetto Scrub Vegetation

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ABSTRACT

In 1983 we sampled using permanent line transects four stands of oak-saw palmetto scrub vegetation that were 2, 4, 8, and 25 years since the previous fire; these transects were resampled two years later. We sampled and analyzed soils from the 0–15 cm and 15–30 cm layer at each transect. The stands were dominated by *Quercus myrtifolia*, *Q. geminata*, *Q. chapmanii*, *Serenoa repens*, and ericaceous shrubs. Species composition was closely related to depth to the water table and related soil parameters as indicated by detrended canonical correspondence analysis ordination of vegetation and environmental data. Postfire recovery was by sprouting of the dominant shrubs with little change in species composition or richness. The initial growth of *Serenoa repens* after fire exceeded that of the oaks, resulting in shifts in dominance postfire. Total cover >0.5 m required six years to reach 100% and 8–10 years to reach a maximum. Total cover <0.5 m increased initially and then declined. Mean height reached one m in four to six years and continued to increase with stand age. Recovery rates have implications for the suitability of this habitat for scrub endemic species.

INTRODUCTION

Scrub vegetation in Florida is the habitat for a number of endangered and threatened animal (Fernald 1989) and plant (Christman and Judd 1990) species. Time since burning and environmental gradients influence composition, structure, and habitat suitability of scrub vegetation. Scrub vegetation dominated by oaks with open sandy spaces and few or no trees is the preferred habitat of the endemic Florida scrub jay (*Aphelocoma coerulescens coerulescens*) (Wescott 1970, Breininger 1981, Cox 1984, Woolfenden and Fitzpatrick 1984), listed as a threatened species by the U.S. Fish and Wildlife Service. The largest remaining population of the Florida scrub jay occurs on Kennedy Space Center (Breininger 1989). Scrub is also habitat for the gopher tortoise (*Gopherus polyphemus*) and other vertebrate species of conservation concern (Breininger et al. 1988). In this paper, we examine the effects of environmental gradients and time since fire on composition and structure of oak-saw palmetto scrub vegetation from a coastal peninsula site in Florida. We also compare composition and structure of this scrub to other scrub vegetation in Florida and similar shrub ecosystems. Myers (1990) noted three major geographic groupings of scrub in Florida; inland peninsula, coastal peninsula, and coastal Panhandle.

Florida scrub vegetation includes a number of distinctive vegetation types (Harper 1914, 1921, 1927; Mulvania 1931; Webber 1935; Kurz 1942; Duever 1983;

Myers 1990). Features uniting these types are generally said to include: 1) the presence of a shrub layer of evergreen, typically sclerophyllous-leaved species including oaks (e.g., *Quercus myrtifolia, Q. chapmanii, Q. geminata*), ericads (e.g., *Lyonia fruticosa, L. ferruginea, Vaccinium myrsinites*), repent palms (e.g., *Serenoa repens, Sabal etonia*), and others such as *Ceratiola ericoides* (Mulvania 1931, Webber 1935, Laessle 1942); 2) occurrence on xeric or at least well-drained sites on sandy soils low in nutrients (Laessle 1958, Myers 1990); and 3) fire dynamics marked by periodic, intense fires rather than frequent, low-intensity fires characteristic of longleaf pine/wiregrass (sandhill) vegetation (Webber 1935, Laessle 1967, Doren et al. 1987, Myers 1990).

There is a diversity of scrub vegetation types and community nomenclature has varied. Sand pine scrub has a canopy of *Pinus clausa* over the evergreen shrub layer (Laessle 1942, 1958, 1967). Similar communities without the sand pine canopy have been termed scrubby flatwoods (Laessle 1942; Abrahamson 1984a, 1984b; Abrahamson et al. 1984; Givens et al. 1984; Abrahamson and Hartnett 1990). Kurz (1942) used the term scrub broadly for various communities of evergreen shrubs on coastal and inland dunes. Webber (1935) emphasized the importance of the shrub layer rather than the pine overstory in defining scrub. Sand pine scrub is nearly endemic to Florida (Austin 1976, Christensen 1979), but related oak scrub communities occur in adjacent states (Laessle 1967, Turner and Bratton 1987, Davison and Bratton 1988). Scrub communities are discontinuously distributed in Florida (Davis 1967, Christman and Judd 1990, Myers 1990). Scrub vegetation has long been present in Florida, at least along the central Florida ridge (Watts 1971, 1975, 1980).

Scrub vegetation is fire-adapted and fire-maintained. Fires are infrequent in sand pine scrub; a return cycle of 20 to 40 or more years has been suggested (Austin 1976). Sand pine reproduces from seed following fire (Webber 1935) and frequent fire can eliminate it (Richardson 1977, Peroni and Abrahamson 1986). However, sand pine is a short-lived species (ca. 75 years) and long exclusion of fire can also lead to its elimination (Laessle 1967). Rosemary (*Ceratiola ericoides*) reproduces only from seed and appears adapted to a fire cycle of greater than 10 but less than 40 years (Johnson 1982), indicating limits to the natural fire cycle of scrub in which it is important. Natural fire frequencies required for oak and oak-saw palmetto scrub communities are not known with certainty. It is thought that oak scrub once burned more often than sand pine scrub but less often than the 2–5 year cycle of longleaf pine/wiregrass (sandhill) (Abrahamson et al. 1984). Natural fires in some scrub communities may have occurred mainly during periodic droughts (Davison and Bratton 1986, 1988; Turner and Bratton 1987).

STUDY AREA

John F. Kennedy Space Center (KSC) lies on the northern part of Merritt Island on the east coast of central Florida at 28°38'N, 80°42'W and consists of about 57,000 ha of land and open water lagoons (Figure 1). The National Aeronautics and Space Administration (NASA) acquired the northern part of Merritt Island in 1962 (NASA 1979). Lands not actively used in the space program are managed by the U.S. Fish and Wildlife Service (USFWS) as Merritt Island

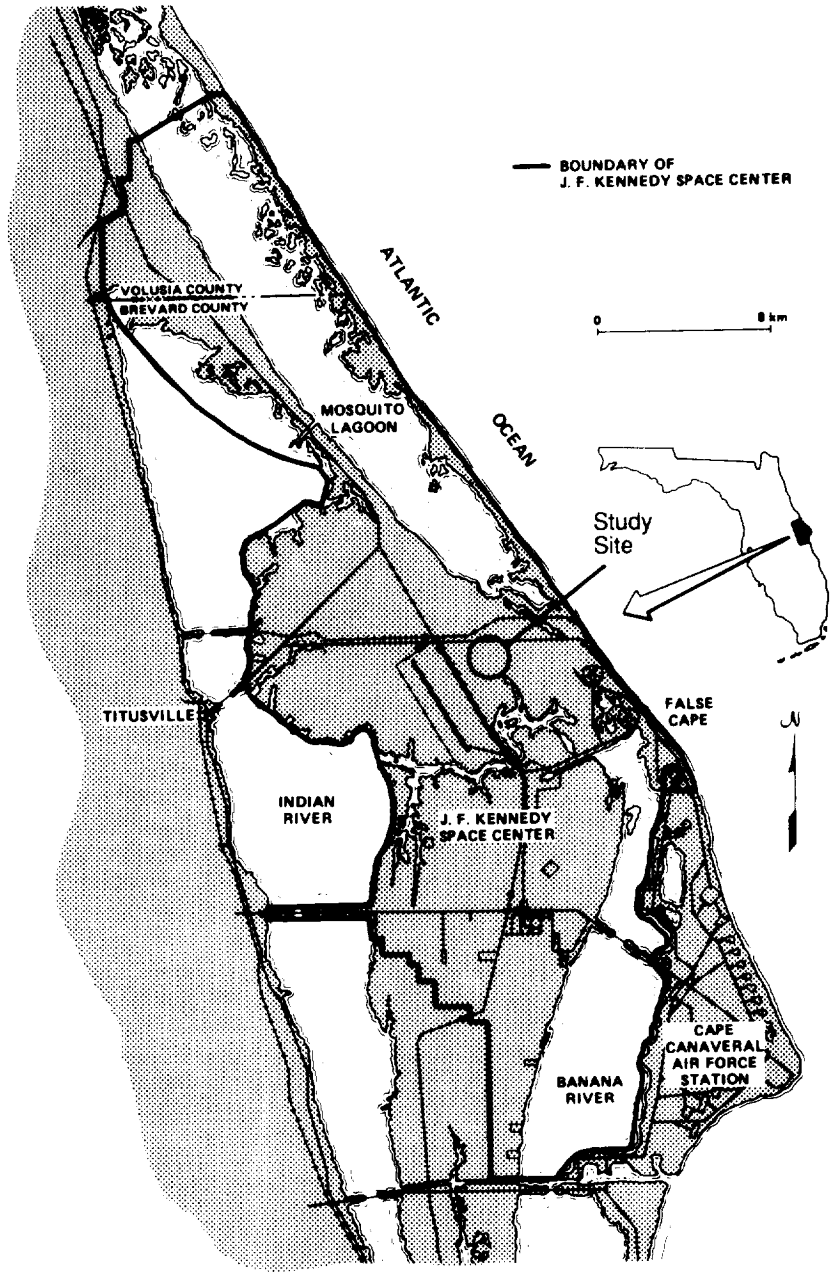

Figure 1. Location of the study site on John F. Kennedy Space Center.

National Wildlife Refuge (MINWR) or by the National Park Service as Canaveral National Seashore.

Merritt Island and the adjacent Cape Canaveral form a barrier island complex. Elevation ranges from sea level to about 3 m (10 ft) in the inland areas of Merritt Island and to slightly over 6 m (20 ft) on Cape Canaveral and the recent dunes. Surface deposits are primarily sand and sandy coquina (Brown et al. 1962) and support a surficial aquifer that is recharged by local rainfall. The water table fluctuates seasonally with precipitation and evapotranspiration (Edward E. Clark Engineers-Scientists, Inc. 1987).

Merritt Island-Cape Canaveral is a prograding barrier island complex (White 1958, 1970). Multiple dune ridges parallel to the present shore inland on Merritt Island apparently represent successive stages in this growth. Successively older landscapes occur westward (inland) on Merritt Island (Brown et al. 1962). Cape Canaveral is of Holocene age, mostly less than 4,500 years old, but Merritt Island is Pleistocene (Osmond et al. 1970, Brooks 1981).

Soil development reflects the differing ages of the landscape as well as drainage and parent material influences (Huckle et al. 1974). On the inland ridges that support scrub vegetation on Merritt Island, the main soils are the excessively drained Paola sand (Spodic Quartzipsamment) and the moderately well drained Pomello sand (Arenic Haplahumod). Both soils are acid, low in nutrients, and leached of shell fragments. On less well drained sites, Immokalee sand (Arenic Haplaquod), Myakka sand (Aeric Haplaquod), and associated series are the major soils. Immokalee is slightly better drained than Myakka. These series are related along a catena from well to poorly drained where development of the spodic horizon (Bh layer) increases, and its position becomes closer to the surface (Huckle et al. 1974).

Merritt Island has a warm, humid climate. Annual precipitation averages 131 cm and ranges from 5.64 cm (Jan) to 20.22 cm (Sept). Mean daily maximum temperatures are 22.3°C for January and 33.3°C for July; mean daily minimum temperatures are 9.5°C for January and 21.8°C for July. Freezing temperatures may occur in winter but do not persist (Provancha et al. 1986a). Thunderstorms are common in the summer months and lightning strikes are frequent (Eastern Space and Missile Center 1989). Long-term precipitation data indicate high year-to-year variability and periodic occurrences of drought (Mailander 1990).

Merritt Island contains a diverse flora with species of temperate and subtropical distribution (Poppleton et al. 1977). Before the 1970's little detailed information was available on the vegetation of Merritt Island. Historical impacts on the vegetation of the Merritt Island area before its acquisition by NASA included logging of live oak and slash pine, drainage of wetlands, land clearing for agriculture, increased fire frequency, and grazing by cattle and hogs (Davison and Bratton 1986). Harper (1921) briefly surveyed Merritt Island and the adjacent mainland. Kurz (1942) described the sequence of vegetation on recent and inland (older) dunes on Cape Canaveral. Sweet (1976) and Stout (1980) described vegetation of the area. The recent vegetation map of Kennedy Space Center (1: 9,600) (Provancha et al. 1986b) estimates that 6,830 ha of scrub occur on KSC of which about 1,284 ha are oak scrub and 5,546 ha are saw palmetto (*Serenoa repens*) scrub. These types vary along environmental gradients and are collectively termed oak-saw palmetto scrub. Only minor areas (<9 ha) of sand pine scrub occur. A general policy of fire suppression was in effect between 1963 and 1975 at which time limited prescribed burning was initiated. After severe wildfires during the 1981 drought, a more extensive prescribed burning program was instituted, providing a three-year fire cycle for most upland vegetation (Lee et al. 1981, Adrian et al. 1983).

METHODS

Vegetation and Soil Sampling

We selected four stands of oak-saw palmetto scrub in January 1983 in the same area of Merritt Island on generally similar sites (Figure 1) that differed in the time since the last fire. Stand 1 was eight years since the previous fire and had oaks one to two m tall (Figure 2). Stand 2 had burned four years (Figure 3) and Stand 3 had burned two years before sampling (Figure 4). Stand 4 was about 25 years old with oaks several meters high (Figure 5). The time since fire of Stands 2 and 3 was determined from USFWS/MINWR fire records and that of Stands 1 and 4 from dating by ring counts trunks of myrtle (*Quercus myrtifolia*) or sand live oak (*Quercus geminata*) harvested during biomass sampling (Schmalzer and Hinkle 1987).

We sampled stands in January 1983 using permanent 15 m line transects. We placed six transects in each stand; one transect in Stand 1 was disturbed before sampling. We recorded percent cover by species in two height classes, 0 to 0.5 m and >0.5 m (Mueller-Dombois and Ellenberg 1974), and determined height of the vegetation at four points (0, 5, 10, and 15 m) along each transect. Vegetation sampling along these permanent transects was repeated in January 1985. The stands did not burn during that interval.

We sampled soils from the 0–15 cm and 15–30 cm layers near each transect; two samples were taken—one from near the transect and one from a nearby biomass sample plot (Schmalzer and Hinkle 1987). Samples were air-dried prior to analyses. Soil pH was determined on a 1:1 soil to water slurry (McLean 1982). Conductivity was measured on a 1:5 soil to water solution (Rhoades 1982). Exchangeable cations (calcium, magnesium, potassium, and sodium) were extracted in neutral 1 N ammonium acetate (Knudson et al. 1982, Lanyon and Heald 1982) and analyzed by atomic absorption spectrophotometer (Perkin-Elmer Corporation 1982). Exchangeable aluminum was extracted in 1N potassium chloride (Barnhisel and Bertsch 1982) and analyzed by atomic absorption spectrophotometer (Perkin-Elmer Corporation 1982). Available metals (Cu, Fe, Mn, and Zn) were extracted in diethylenetriaminepentaacetic acid (DTPA) (Olson and Ellis 1982, Gambrell and Patrick 1982, Baker and Amacher 1982) and analyzed by atomic absorption spectrophotometer (Perkin-Elmer Corporation 1982). Available phosphorus was determined by extraction in deionized water (Olsen and Sommers 1982) followed by analysis on an autoanalyzer (Technicon Industrial Systems 1983c). Exchangeable NO_3-N and NH_4-N were extracted in 2N potassium chloride (Keeney and Nelson 1982) and then analyzed on an autoanalyzer (Technicon Industrial Systems 1973, 1983a). Total Kjeldahl nitrogen (TKN) was determined by micro-Kjeldahl digestion (Schuman et al. 1973) followed by

Figure 2. Scrub Stand 1 at eight years since fire. The marker post is about 1.7 m in height.

analysis on an autoanalyzer (Technicon Industrial Systems 1983b). Percent organic matter was determined by combustion (Nelson and Sommers 1982). Cation exchange capacity (CEC) was determined by an ammonium saturation method (Chapman 1965) followed by analysis of ammonium as above.

We determined depth to the water table by coring with a soil auger near each transect until saturated soil was reached. Depths to the water table were determined seasonally. Elevation was estimated for each transect to the nearest 5 ft (1.5 m) contour from topographic maps (Orsino and Wilson 7.5′ quadrangles). We located transects on soil maps (Huckle et al. 1974) and determined soil types.

Data Analysis

We examined relationships between species composition and environmental variables using the 1983 vegetation data (>0.5 m) and detrended canonical correspondence analysis (DCCA) in the CANOCO package (Ter Braak 1988, 1990). Canonical correspondence analysis (CCA) (Ter Braak 1986, 1987a, 1987b) relates a set of species to a set of environmental variables. Placement of species and samples in this ordination is determined by both vegetation and environmental data. Preliminary analyses indicated a consistent arch effect due to correlations among the environmental variables (Ter Braak 1986, 1988) that could not readily be removed by deleting selected variables; therefore, detrending was used. Depth to the water table in summer was omitted because it was highly correlated ($r = 0.896$) with spring water table depth. Soil data used were from the 0–15 cm layer.

To examine patterns of compositional change in vegetation between the

Figure 3. Scrub Stand 2 at four years since fire.

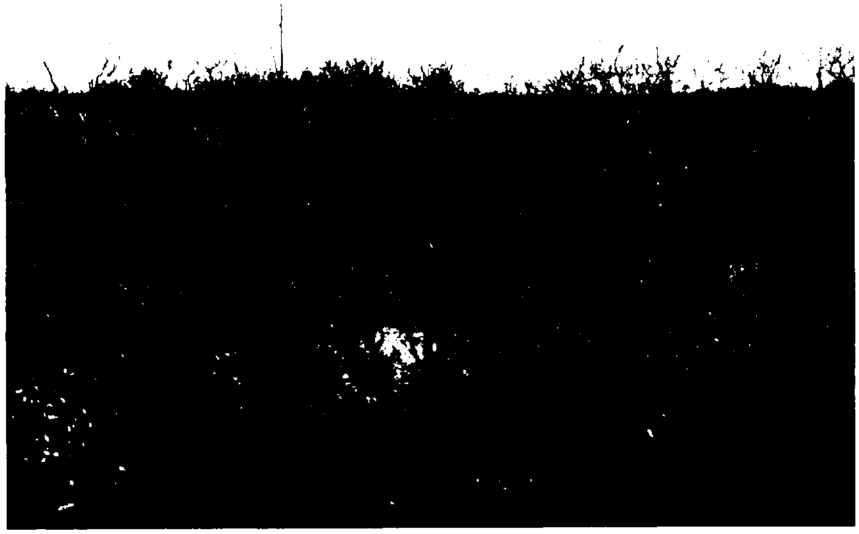

Figure 4. Scrub Stand 3 at two years since fire. Note standing dead stems and patches of bare ground.

two sampling times, we combined data from the 1983 and 1985 samples (>0.5 m) and used detrended correspondence analysis (DCA) ordination (Hill and Gauch 1980, Gauch 1982) in the CANOCO package (Ter Braak 1988, 1990). We used an option in CANOCO to make the 1985 samples passive. Passive samples have no influence on the extraction of the ordination axes but are added afterward using transition formulae (Ter Braak 1988). Thus, the structure of this ordination was determined by the 1983 vegetation samples only, and the 1985 samples were located relative to them. Environmental data were not involved in this ordination.

RESULTS

Community Composition-Environmental Variation

Detrended canonical correspondence analysis ordination gave high species–environment correlations (Table 1) for the first two axes. The first axis, with the largest eigenvalue (Table 1) and a high species-environment correlation, was clearly the most important. In the DCCA ordination, scrub oaks occurred on the left of the ordination diagram (Figure 6) with saw palmetto to the right and *Ilex glabra* and *Persea borbonia* at the extreme right. Depth to water table, soil organic matter, cation exchange capacity, and many soil nutrients were positively correlated with the first ordination axis (Table 2); stand age, pH and aluminum were negatively correlated. Environmental variation (Figure 7) corresponding with the vegetation pattern was related to depths to the water table and correlated soil variables including soil organic matter and most soil nutrients (K, P, Ca,

Figure 5. Scrub Stand 4 at about 25 years since fire.

Table 1. **Detrended canonical correlation analysis ordination of scrub vegetation and environmental data**

	Axis 1	Axis 2	Axis 3
Eigenvalue[1]	0.423	0.124	0.063
Species-Environment Correlation	0.978	0.932	0.866
Cumulative Percent Variance of Species Data	37.7	48.8	54.4
Cumulative Percent Variance of Species-Environment Data	44.9	58.0	64.7

[1] Sum of all unconstrained eigenvalues = 1.122

Mg). In this diagram, longer arrows indicate greater correlation between the variable and the ordination axes (Ter Braak 1986). Sites on the right of the ordination were the wettest, that is they had shallow depth to water table (small negative numbers). The angle between vectors in this diagram is a measure of the correlation between environmental variables; variables separated by small angles are highly correlated (Ter Braak 1987b). Many of the soil nutrients were correlated among themselves and to the depth to the water table.

As suggested by the DCCA ordination, environmental and soil variables differed among the four stands (Table 3). Since two transects of Stand 2 appeared distinct in the ordination, they were treated separately. The water table was always closest to the surface in the saw palmetto-dominated transects of Stand 2. Soil organic matter, conductivity, CEC, exchangeable cations (Ca, Mg, K, Na), TKN, available P, and exchangeable NH_4-N were substantially higher in the saw palmetto-dominated transects of Stand 2 than elsewhere (Table 3). Available Fe

Table 2. **Correlations between environmental variables and the first two ordination axes**

Variable	Correlation Axis 1	Coefficients Axis 2
Depth to Water Table—Spring	0.788	−0.431
Depth to Water Table—Fall	0.500	−0.134
Depth to Water Table—Winter	0.557	−0.464
Stand Age	−0.758	0.273
pH	−0.237	−0.165
Conductivity	0.603	0.200
Organic Matter	0.689	0.042
Cation Exchange Capacity	0.609	0.142
Phosphorus	0.719	−0.045
Total Kjeldahl Nitrogen	0.655	−0.056
Nitrate-Nitrogen	0.237	−0.387
Ammonium-Nitrogen	0.348	−0.139
Calcium	0.472	−0.246
Magnesium	0.724	−0.016
Potassium	0.633	0.127
Aluminum	−0.187	0.053

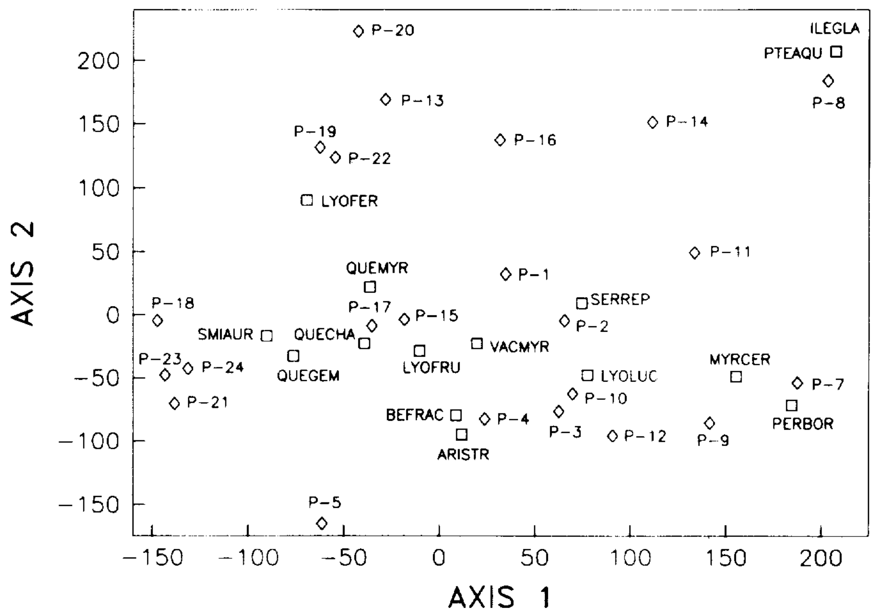

Figure 6. Detrended canonical correspondence analysis ordination of scrub vegetation sampled in 1983 showing species and samples. Vegetation data are from the >0.5 m layer. Species are ARISTR (*Aristida stricta*), BEFRAC (*Befaria racemosa*), ILEGLA (*Ilex glabra*), LYOFER (*Lyonia ferruginea*), LYOFRU (*Lyonia fruticosa*), LYOLUC (*Lyonia lucida*), MYRCER (*Myrica cerifera*), PERBOR (*Persea borbonia*), PTEAQU (*Pteridium aquilinum*), QUECHA (*Quercus chapmanii*), QUEGEM (*Quercus geminata*), QUEMYR (*Quercus myrtifolia*), SERREP (*Serenoa repens*), SMIAUR (*Smilax auriculata*), and VACMYR (*Vaccinium myrsinites*). Samples are from Stand 1 (P-1 to P-5), Stand 2 (P-7 to P-12), Stand 3 (P-13 to P-18), and Stand 4 (P-19 to P-24).

and Zn and exchangeable Al were also higher in the saw palmetto transects. All soils were acid, but those of the saw palmetto transects had the lowest pH. Soils of the oak-saw palmetto transects of Stand 2 were somewhat higher in conductivity, organic matter, CEC, TKN, P, Ca, Mg and K but not Na, Fe, or Zn than the other oak-saw palmetto stands. Nitrate-nitrogen, Cu, and Mn showed no trends among stands. The 15–30 cm layer was less acid and lower in conductivity, organic matter, CEC, cations, TKN, NH_4-N, Fe, Mn, and Zn than the 0–15 cm layer.

In Stands 1 and 3 all transects were on soils mapped as Pomello sand. In Stand 4 transects were evenly divided between the Pomello and Paola series. The two saw palmetto-dominated transects of Stand 2 were on Myakka sand; the remaining transects were evenly divided between Pomello and Immokalee sand.

Species composition of the >0.5 m layer was broadly similar across the four stands in 1983 (Table 4), except for two transects in Stand 2 dominated by saw palmetto. Myrtle oak, sand live oak, Chapman oak (*Quercus chapmanii*), saw

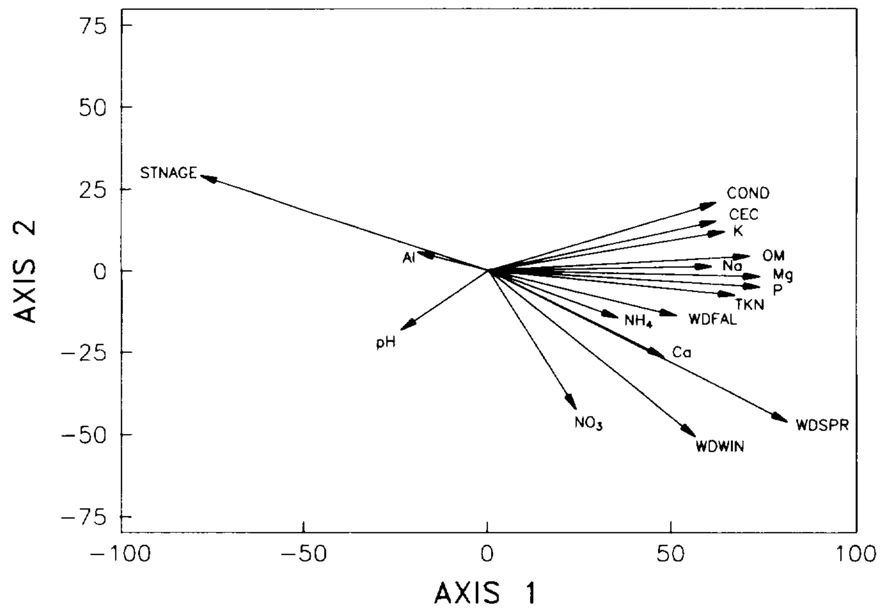

Figure 7. Detrended canonical correspondence analysis ordination of scrub vegetation sampled in 1983 showing environmental variables. Variables are Al (aluminum), Ca (calcium), CEC (cation exchange capacity), COND (conductivity), K (potassium), Mg (magnesium), Na (sodium), NH_4 (ammonium-nitrogen), NO_3 (nitrate-nitrogen), OM (organic matter), P (phosphorus), pH, STNAGE (stand age), WDWIN (depth to water table—winter), WDSPR (depth to water table—spring), and WDFAL (depth to water table—fall).

palmetto, fetterbush (*Lyonia lucida*), staggerbush (*Lyonia fruticosa*), and rusty lyonia (*Lyonia ferruginea*) were the most important species. *Ilex glabra* (gallberry) and *Persea borbonia* (red bay) occurred only in the saw palmetto-dominated transects of Stand 2. In the <0.5 m layer, the most common species were sprouts of the larger shrubs, small shrubs such as shiny blueberry (*Vaccinium myrsinites*), and wiregrass (*Aristida stricta*) (Table 5).

Vegetation Changes

Species composition in 1985 was similar to that in 1983 (Tables 4, 5). In the youngest stand (Stand 3) and in the oak-saw palmetto transects of Stand 2, the cover of scrub oaks (>0.5 m) increased between 1983 and 1985 (Table 4). In the older stands (1 and 4), changes in species cover (>0.5 m) were minor (Table 4). Conversely, in the younger stands (2 and 3) many species decreased in cover in the <0.5 m layer (Table 5) as they grew into the higher layer or as thinning occurred.

The ordination pattern shown by DCA was similar to that given by DCCA except that the transects and species of wetter sites occurred to the left rather than the right of the ordination diagrams. In the DCA ordination of data from the two sampling times (Figure 8), the oak-saw palmetto transects of Stand 2

Table 3. Selected environmental and soil variables in the scrub stands

	Stand 1	Stand 2 Oak-Saw Palmetto	Stand 2 Saw Palmetto	Stand 3	Stand 4
Transects	P1–P5	P9–P12	P7–P8	P13–P18	P19–P24
Stand Age (yr)	8	4	4	2	25
Variable	N = 5 $\bar{x}$ (SD)	N = 4 $\bar{x}$ (SD)	N = 2 $\bar{x}$ (SD)	N = 6 $\bar{x}$ (SD)	N = 6 $\bar{x}$ (SD)
Environmental Variables					
Elevation (m)	2.1 (0.0)	2.1 (0.0)	1.5 (0.0)	2.1 (0.0)	2.1 (0.0)
0 Horizon Thickness (cm)	0.9 (0.4)	0.0 (0.0)	0.0 (0.0)	0.2 (0.4)	1.1 (0.5)
Spring Water Table Depth (cm)	−53.8 (11.5)	−42.0 (30.4)	−19.5 (13.4)	−93.2 (11.9)	−131.2 (9.2)
Summer Water Table Depth (cm)	−82.0 (21.4)	−77.8 (55.4)	−38.5 (9.2)	−114.0 (23.0)	−146.2 (23.9)
Fall Water Table Depth (cm)	−108.2 (22.9)	−45.8 (24.2)	−20.0 (0.0)	−72.8 (9.1)	−95.2 (15.6)
Winter Water Table Depth (cm)	−55.4 (9.7)	−88.3 (11.7)	−70.5 (20.5)	−111.7 (18.8)	−135.8 (25.4)

Table 3. Continued

		Stand 1	Stand 2 Oak-Saw Palmetto	Stand 2 Saw Palmetto	Stand 3	Stand 4
Transects		P1–P5	P9–P12	P7–P8	P13–P18	P19–P24
Stand Age (yr)		8	4	4	2	25
Variable	**Horizon (cm)**	N = 12 $\bar{x}$ (SD)	N = 8 $\bar{x}$ (SD)	N = 4 $\bar{x}$ (SD)	N = 12 $\bar{x}$ (SD)	N = 12 $\bar{x}$ (SD)
			Soil Variables			
Hydrogen Ion	0–15	1.17038 E−4 (7.7920 E−5)	1.42272 E−4 (6.4362 E−5)	1.60761 E−4 (7.3796 E−5)	4.6572 E−5 (3.5042 E−5)	8.5698 E−5 (5.6978 E−5)
	15–30	3.1372 E−5 (1.2992 E−5)	7.9337 E−5 (2.8787 E−5)	8.9879 E−5 (3.5907 E−5)	2.5878 E−5 (2.1260 E−5)	4.5952 E−5 (2.6250 E−5)
pH	0–15	3.93	3.85	3.79	4.33	4.07
	15–30	4.50	4.10	4.05	4.59	4.34
Conductivity (μmhos/cm)	0–15	58.0 (15.6)	77.0 (22.9)	131.3 (32.2)	36.6 (10.3)	54.9 (13.6)
	15–30	23.5 (8.2)	36.7 (16.1)	54.8 (16.1)	22.8 (5.0)	24.6 (5.5)
Organic Matter (%)	0–15	3.6 (1.8)	7.1 (3.7)	15.3 (4.4)	1.8 (0.7)	3.3 (1.3)
	15–30	0.6 (0.5)	2.0 (1.4)	5.4 (5.6)	1.3 (1.5)	1.2 (0.7)
Cation Exchange Capacity (meq/100 g)	0–15	0.45 (0.34)	1.46 (2.96)	9.98 (6.38)	0.27 (0.30)	0.31 (0.16)
	15–30	0.21 (0.25)	0.39 (0.60)	0.69 (0.43)	0.19 (0.13)	0.21 (0.09)

Table 3. Continued

		Stand 1	Stand 2 Oak-Saw Palmetto	Stand 2 Saw Palmetto	Stand 3	Stand 4
Transects		P1–P5	P9–P12	P7–P8	P13–P18	P19–P24
Stand Age (yr)		8	4	4	2	25
Variable	**Horizon (cm)**	**N = 12 $\bar{x}$ (SD)**	**N = 8 $\bar{x}$ (SD)**	**N = 4 $\bar{x}$ (SD)**	**N = 12 $\bar{x}$ (SD)**	**N = 12 $\bar{x}$ (SD)**
Phosphorus (mg/kg)	0–15	3.17	5.51	19.00	0.90	1.77
		(2.11)	(2.06)	(4.85)	(0.90)	(1.22)
	15–30	0.90	1.76	4.13	0.20	0.30
		(1.12)	(1.34)	(1.09)	(0.24)	(0.32)
Calcium (mg/kg)	0–15	111.35	174.98	222.10	54.73	55.08
		(133.05)	(112.28)	(71.42)	(24.87)	(11.92)
	15–30	21.63	45.43	62.10	25.90	22.37
		(11.19)	(26.78)	(15.53)	(11.75)	(5.35)
Magnesium (mg/kg)	0–15	31.55	54.97	184.06	12.21	12.97
		(23.61)	(27.52)	(41.84)	(7.77)	(4.39)
	15–30	4.39	17.00	39.22	3.83	3.52
		(2.73)	(15.22)	(12.52)	(2.04)	(1.30)
Potassium (mg/kg)	0–15	31.82	39.38	106.10	18.55	29.78
		(13.70)	(11.18)	(51.66)	(7.12)	(12.81)
	15–30	10.05	17.10	24.70	10.13	8.20
		(7.20)	(12.91)	(4.28)	(4.12)	(2.72)
Sodium (mg/kg)	0–15	20.16	26.40	65.03	16.57	20.46
		(4.16)	(6.42)	(15.84)	(4.01)	(5.08)
	15–30	13.00	16.41	30.82	12.51	12.48
		(3.20)	(6.39)	(9.90)	(1.60)	(1.41)

Table 3. Continued

		Stand 1	Stand 2 Oak-Saw Palmetto	Stand 2 Saw Palmetto	Stand 3	Stand 4
Transects		P1–P5	P9–P12	P7–P8	P13–P18	P19–P24
Stand Age (yr)		8	4	4	2	25
Total Kjeldahl	0–15	449.28	788.63	2,237.00	201.16	290.51
Nitrogen (mg/kg)		(212.80)	(391.04)	(327.89)	(86.51)	(92.88)
	15–30	65.26	217.37	346.99	83.67	92.04
		(19.61)	(178.08)	(106.88)	(45.78)	(36.27)
Nitrate-nitrogen	0–15	0.71	0.66	0.77	0.64	0.52
(mg/kg)		(0.25)	(0.15)	(0.25)	(0.48)	(0.11)
	15–30	0.75	0.55	0.48	0.45	0.49
		(0.33)	(0.12)	(0.08)	(0.09)	(0.07)
Ammonium-nitrogen	0–15	10.23	12.21	48.35	6.31	10.13
(mg/kg)		(3.86)	(4.89)	(23.67)	(7.78)	(7.89)
	15–30	2.50	4.60	6.13	1.57	2.18
		(0.96)	(3.08)	(1.23)	(0.39)	(0.94)
Aluminum (mg/kg)	0–15	6.83	4.88	15.80	7.10	9.27
		(5.17)	(3.48)	(6.90)	(5.30)	(7.82)
	15–30	2.77	7.33	6.10	8.73	7.82
		(5.31)	(6.04)	(2.41)	(9.06)	(5.87)
Copper (mg/kg)	0–15	0.12	0.13	0.13	0.07	0.09
		(0.02)	(0.05)	(0.04)	(0.03)	(0.03)
	15–30	0.10	0.08	0.10	0.06	0.07
		(0.05)	(0.02)	(0.07)	(0.02)	(0.05)

Table 3. Continued

		Stand 1	Stand 2 Oak-Saw Palmetto	Stand 2 Saw Palmetto	Stand 3	Stand 4
Transects		P1–P5	P9–P12	P7–P8	P13–P18	P19–P24
Stand Age (yr)		8	4	4	2	25
Variable	**Horizon (cm)**	**N = 12 $\bar{x}$ (SD)**	**N = 8 $\bar{x}$ (SD)**	**N = 4 $\bar{x}$ (SD)**	**N = 12 $\bar{x}$ (SD)**	**N = 12 $\bar{x}$ (SD)**
Iron (mg/kg)	0–15	16.22	27.30	54.57	21.35	29.45
		(10.39)	(11.42)	(36.42)	(12.59)	(19.00)
	15–30	9.45	10.34	14.40	9.79	13.05
		(15.44)	(12.61)	(9.43)	(6.95)	(7.62)
Manganese (mg/kg)	0–15	1.66	1.44	1.03	0.85	0.83
		(2.54)	(1.21)	(0.86)	(0.58)	(0.30)
	15–30	0.17	0.17	0.13	0.15	0.16
		(0.20)	(0.13)	(0.14)	(0.16)	(0.09)
Zinc (mg/kg)	0–15	0.622	0.627	0.947	0.312	0.510
		(0.438)	(0.247)	(0.692)	(0.157)	(0.195)
	15–30	0.193	0.146	0.165	0.099	0.145
		(0.214)	(0.115)	(0.025)	(0.066)	(0.069)

and five of six transects in Stand 3 shifted to the right in the ordination diagram (Figure 8) between 1983 and 1985, that is toward the oak-dominated end of the gradient. The two saw palmetto-dominated transects shifted to the left of the ordination, reflecting increases in cover of *Ilex glabra* and *Persea borbonia*. In contrast, transects of the older stands (1 and 4) showed little change.

Species richness (mean number of species per transect) changed little between stands or between the two samples of the same stand. There was an increase in number of species in the >0.5 m layer in the younger stands from 1983 to 1985 (Table 4) and a decrease in the <0.5 m layer (Table 5). Considering both layers together, there were no significant differences in species richness with time (Figure 9).

Community Structure

Structural changes in the plant communities continued to occur with time since fire. Mean total cover in the >0.5 m layer increased rapidly until about eight years postfire and then leveled off (Table 4). In the <0.5 m layer, cover decreased from years two through six and then fluctuated (Table 5). Mean height (Figure 10) increased rapidly at first and then at a slower rate.

DISCUSSION

Community Composition-Environmental Variation

Composition of scrub communities on KSC is closely related to depth to the water table. Along the increasing depth to water table gradient, dominance of scrub oaks increases and that of saw palmetto decreases. Depth to the water table is a complex gradient involving water availability, soil aeration, and the occurrence and duration of seasonally wet soils. In addition, soil organic matter and nutrients increase in the wetter soils. Detrended canonical correspondence analysis provides confirmation of relationships shown in previous analyses (Schmalzer and Hinkle 1987). Stand age was also significantly correlated to the ordination pattern; however, the oldest stand occurred on the driest site. The youngest stand also had high oak dominance, particularly as time since fire increased. Time since fire has less influence on species composition but affects dominance patterns, since saw palmetto regrows more rapidly after fire than the scrub oaks. Subsequent work (Schmalzer and Hinkle 1991, 1992) supports this conclusion.

The saw palmetto-dominated transects of Stand 2 are outside the usual boundaries of scrub vegetation and resemble mesic flatwoods but lack a pine canopy. Such shrublands are important in scrub landscapes on KSC and are often in close proximity to better drained, oak-dominated areas. The other transects of Stand 2 are of mixed dominance. In these, oak cover is influenced by time since fire, increasing sharply during the study.

Some features of oak-saw palmetto scrub vegetation on Merritt Island differ from inland scrubs previously studied. Few open areas occur in undisturbed oak-saw palmetto scrub on Merritt Island unlike the openings described in sand pine scrub (Webber 1935, Mulvania 1931). Many of the endemic species of scrub plants occurring on the Lake Wales Ridge (Abrahamson et al. 1984, Christman and Judd 1990) do not occur in oak-saw palmetto scrub on Merritt Island. Although

Table 4. Composition (percent cover) of the >0.5 m height layer of the scrub stands in 1983 and 1985

	Stand 1		Stand 2 Oak-Saw Palmetto		Stand 2 Saw Palmetto		Stand 3		Stand 4	
Transects	P1–P5		P9–P12		P7–P8		P13–P18		P19–P24	
Stand Age (yr)	8	10	4	6	4	6	2	4	25	27
Species	1983 N = 5 x̄ (SD)	1985 N = 5 x̄ (SD)	1983 N = 6 x̄ (SD)	1985 N = 6 x̄ (SD)	1983 N = 2 x̄ (SD)	1985 N = 2 x̄ (SD)	1983 N = 6 x̄ (SD)	1985 N = 6 x̄ (SD)	1983 N = 6 x̄ (SD)	1985 N = 6 x̄ (SD)
Aristida stricta	5.6	1.7	0.9	0.7	—	0.4	—	—	—	—
	(6.3)	(2.2)	(1.3)	(1.4)	—	(0.5)	—	—	—	—
Befaria racemosa	1.0	0.9	0.9	1.9	—	1.7	0.6	1.5	—	0.4
	(1.4)	(1.3)	(1.7)	(2.8)	—	(2.3)	(1.5)	(3.6)	—	(1.1)
Ilex glabra	—	—	—	—	3.4	13.7	—	—	—	—
	—	—	—	—	(4.7)	(0.5)	—	—	—	—
Lyonia ferruginea	—	—	—	—	—	—	1.0	3.8	11.1	11.4
	—	—	—	—	—	—	(1.2)	(3.5)	(6.7)	(7.4)
L. fruticosa	2.5	3.1	0.4	2.7	—	—	—	—	0.9	0.3
	(1.6)	(2.7)	(0.9)	(3.3)	—	—	—	—	(1.4)	(0.8)
L. lucida	17.8	14.7	13.4	16.2	11.0	7.0	—	0.3	0.5	0.4
	(7.0)	(7.1)	(8.6)	(12.4)	(8.9)	(1.4)	—	(0.8)	(0.8)	(1.1)
Myrica cerifera	—	0.7	—	0.7	2.7	3.7	—	0.1	0.1	0.7
	—	(0.7)	—	(0.9)	(3.7)	(5.2)	—	(0.3)	(0.3)	(1.6)
Persea borbonia	—	—	—	—	0.7	2.0	—	—	—	—
	—	—	—	—	(0.9)	(2.8)	—	—	—	—
Pteridium aquilinum	—	—	—	—	0.4	—	—	—	—	—
	—	—	—	—	(0.5)	—	—	—	—	—
Quercus chapmanii	9.1	7.1	0.4	2.0	1.0	—	1.6	8.1	7.5	12.1
	(5.2)	(3.3)	(0.9)	(1.7)	(1.4)	—	(2.4)	(4.5)	(9.3)	(10.1)

Table 4. Continued

Transects	Stand 1 P1–P5		Stand 2 Oak-Saw Palmetto P9–P12		Stand 2 Saw Palmetto P7–P8		Stand 3 P13–P18		Stand 4 P19–P24	
Stand Age (yr)	8	10	4	6	4	6	2	4	25	27
Species	1983 N = 5 x̄ (SD)	1985 N = 5 x̄ (SD)	1983 N = 6 x̄ (SD)	1985 N = 6 x̄ (SD)	1983 N = 2 x̄ (SD)	1985 N = 2 x̄ (SD)	1983 N = 6 x̄ (SD)	1985 N = 6 x̄ (SD)	1983 N = 6 x̄ (SD)	1985 N = 6 x̄ (SD)
Q. myrtifolia	36.9	42.4	6.9	26.5	—	—	12.8	37.3	52.6	53.2
	(8.9)	(8.1)	(5.2)	(22.6)	—	—	(5.6)	(13.1)	(12.7)	(9.6)
Q. geminata	14.9	12.6	6.6	13.1	0.2	1.7	3.2	11.6	35.0	27.8
	(21.9)	(19.1)	(9.3)	(16.7)	(0.2)	(2.3)	(5.6)	(9.9)	(25.1)	(22.5)
Serenoa repens	34.0	30.0	36.7	34.3	68.0	73.3	12.4	10.6	12.6	8.9
	(12.0)	(14.1)	(6.9)	(10.3)	(24.5)	(17.0)	(10.8)	(8.2)	(14.0)	(10.1)
Smilax auriculata	0.7	—	—	—	—	—	—	1.8	4.1	1.8
	(1.5)	—	—	—	—	—	—	(2.8)	(4.2)	(2.3)
Vaccinium myrsinites	0.3	0.3	—	—	—	—	—	—	—	—
	(0.6)	(0.6)	—	—	—	—	—	—	—	—
V. stamineum	—	—	—	—	—	—	—	0.3	—	0.1
	—	—	—	—	—	—	—	(0.8)	—	(0.3)
Ximenia americana	—	—	—	—	—	—	—	—	—	0.2
	—	—	—	—	—	—	—	—	—	(0.5)
Total Cover	122.7	113.4	66.1	97.9	87.2	103.3	32.9	75.3	124.3	117.5
	(15.7)	(11.9)	(16.1)	(7.7)	(31.6)	(11.4)	(10.7)	(8.3)	(14.9)	(8.8)
Mean Number of Species per Transect	7.0	7.4	4.5	6.3	5.0	5.5	3.7	5.5	5.8	6.0
	(1.7)	(2.1)	(1.9)	(2.4)	(0.0)	(2.1)	(1.2)	(1.4)	(1.0)	(1.8)

Table 5. Composition (percent cover) of the <0.5 m height layer of the scrub stands in 1983 and 1985

	Stand 1		Stand 2 Oak-Saw Palmetto		Stand 2 Saw Palmetto		Stand 3		Stand 4	
Transects	P1–P5		P9–P12		P7–P8		P13–P18		P19–P24	
Stand Age (yr)	8	10	4	6	4	6	2	4	25	27
Species	1983 N = 5 x̄ (SD)	1985 N = 5 x̄ (SD)	1983 N = 4 x̄ (SD)	1985 N = 4 x̄ (SD)	1983 N = 2 x̄ (SD)	1985 N = 2 x̄ (SD)	1983 N = 6 x̄ (SD)	1985 N = 6 x̄ (SD)	1983 N = 6 x̄ (SD)	1985 N = 6 x̄ (SD)
Bare ground	—	—	—	—	—	—	3.2	0.5	—	0.2
	—	—	—	—	—	—	(3.2)	(0.8)	—	(0.5)
Andropogon spp.	—	—	—	—	1.2	—	—	—	—	—
	—	—	—	—	(1.6)	—	—	—	—	—
Aristida stricta	2.3	1.6	5.0	3.4	6.4	4.7	1.1	0.9	—	—
	(3.3)	(2.2)	(3.5)	(2.3)	(9.0)	(6.6)	(2.4)	(1.9)	—	—
Befaria racemosa	0.3	0.3	0.2	0.3	—	—	0.05	—	—	—
	(0.4)	(0.6)	(0.4)	(0.7)	—	—	(0.1)	—	—	—
Hypericum reductum	—	—	0.3	0.3	—	—	—	—	—	—
	—	—	(0.5)	(0.5)	—	—	—	—	—	—
Ilex glabra	—	—	—	—	1.0	0.4	—	—	—	—
	—	—	—	—	(1.4)	(0.5)	—	—	—	—

Table 5. Continued

Transects	Stand 1 P1–P5		Stand 2 Oak-Saw Palmetto P9–P12		Stand 2 Saw Palmetto P7–P8		Stand 3 P13–P18		Stand 4 P19–P24	
Stand Age (yr)	8	10	4	6	4	6	2	4	25	27
Species	1983 N = 5 x̄ (SD)	1985 N = 5 x̄ (SD)	1983 N = 4 x̄ (SD)	1985 N = 4 x̄ (SD)	1983 N = 2 x̄ (SD)	1985 N = 2 x̄ (SD)	1983 N = 6 x̄ (SD)	1985 N = 6 x̄ (SD)	1983 N = 6 x̄ (SD)	1985 N = 6 x̄ (SD)
Lyonia ferruginea	—	—	—	—	—	—	1.5	0.7	1.3	0.05
	—	—	—	—	—	—	(1.4)	(1.3)	(1.1)	(0.1)
L. fruticosa	0.9	0.9	1.5	0.4	—	0.4	—	0.3	0.2	—
	(1.2)	(1.0)	(2.2)	(0.5)	—	(0.5)	—	(0.5)	(0.5)	—
L. lucida	6.7	1.6	3.3	2.0	2.5	0.4	0.8	0.3	0.9	0.8
	(4.3)	(0.7)	(1.8)	(1.5)	(2.5)	(0.5)	(0.6)	(0.4)	(1.4)	(1.3)
Myrica cerifera	2.0	0.9	3.1	1.3	1.2	—	0.1	0.2	1.2	1.4
	(1.6)	(1.1)	(3.8)	(1.9)	(1.6)	—	(0.3)	(0.5)	(2.4)	(1.3)
Paronychia americana	—	—	—	—	—	—	0.1	0.05	—	—
	—	—	—	—	—	—	(0.3)	(0.1)	—	—
Piloblephis rigida	—	—	—	—	—	—	0.2	—	—	—
	—	—	—	—	—	—	(0.5)	—	—	—
Pteridium aquilinum	1.2	—	—	—	5.5	—	0.9	0.2	1.0	0.1
	(2.3)	—	—	—	(0.3)	—	(1.7)	(0.5)	(1.7)	(0.3)
Quercus chapmanii	1.9	1.6	—	1.2	0.5	—	8.8	4.6	1.3	1.4
	(2.5)	(0.7)	—	(2.4)	(0.7)	—	(4.8)	(2.2)	(1.5)	(1.0)
Q. myrtifolia	8.9	3.1	9.1	2.9	—	—	22.3	13.5	16.5	7.3
	(4.7)	(1.6)	(9.8)	(3.2)	—	—	(9.9)	(9.6)	(3.7)	(3.9)

Table 5. Continued

Transects	Stand 1 P1–P5		Stand 2 Oak-Saw Palmetto P9–P12		Stand 2 Saw Palmetto P7–P8		Stand 3 P13–P18		Stand 4 P19–P24	
Stand Age (yr)	8	10	4	6	4	6	2	4	25	27
Species	1983 N = 5 x̄ (SD)	1985 N = 5 x̄ (SD)	1983 N = 4 x̄ (SD)	1985 N = 4 x̄ (SD)	1983 N = 2 x̄ (SD)	1985 N = 2 x̄ (SD)	1983 N = 6 x̄ (SD)	1985 N = 6 x̄ (SD)	1983 N = 6 x̄ (SD)	1985 N = 6 x̄ (SD)
Q. geminata	2.3 (1.7)	1.3 (1.1)	4.1 (3.1)	1.6 (2.3)	0.2 (0.2)	— —	11.7 (11.0)	3.2 (2.8)	6.8 (5.3)	1.6 (1.4)
Serenoa repens	1.3 (2.0)	0.5 (0.7)	0.7 (1.4)	— —	0.9 (1.2)	— —	0.7 (1.6)	0.3 (0.6)	— —	— —
Smilax auriculata	0.1 (0.3)	0.1 (0.3)	— —	— —	— —	— —	0.4 (1.1)	— —	— —	— —
Vaccinium myrsinites	2.0 (1.9)	1.7 (1.7)	0.9 (1.0)	1.1 (1.6)	0.4 (0.5)	— —	0.3 (0.7)	0.9 (1.0)	2.1 (0.9)	1.5 (1.2)
V. stamineum	— —	— —	— —	— —	— —	— —	— —	0.5 (0.8)	— —	0.1 (0.3)
Ximenia americana	— —	— —	— —	— —	— —	— —	— —	— —	— —	0.2 (0.5)
Total Cover	29.9 (7.1)	13.8 (4.1)	28.2 (11.0)	14.4 (4.4)	19.5 (19.1)	5.7 (8.1)	52.4 (9.5)	26.0 (10.1)	31.3 (5.8)	14.7 (4.0)
Mean Number of Species per Transect	7.8 (1.5)	7.2 (1.1)	6.2 (1.0)	5.8 (1.5)	6.0 (5.7)	2.0 (2.8)	6.2 (2.5)	6.2 (2.9)	5.7 (1.0)	5.5 (0.8)

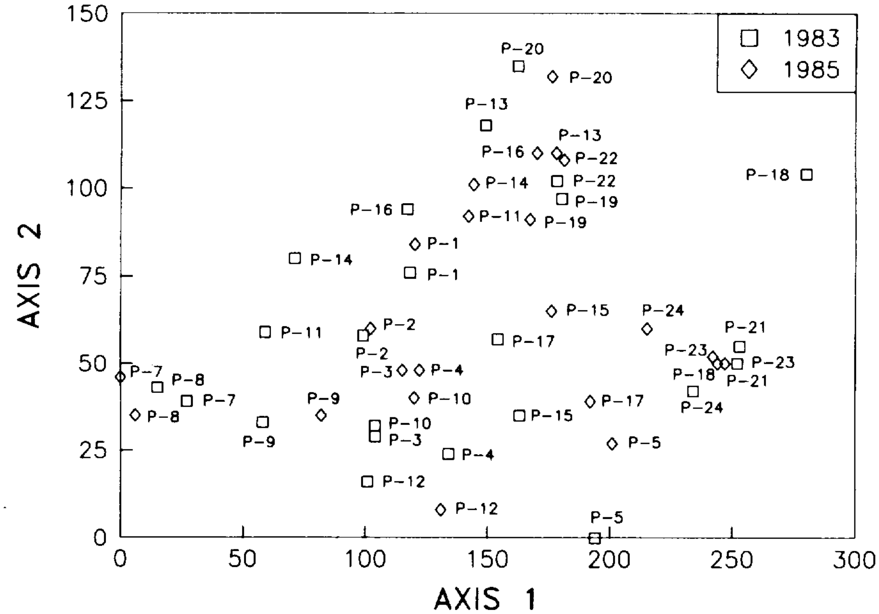

Figure 8. Detrended correspondence analysis stand ordination of scrub vegetation (>0.5 m layer) sampled in 1983 and 1985. Ordination structure was determined by the 1983 samples with 1985 samples located passively in relation to them.

rosemary and scrub hickory (*Carya floridana*) occur on Cape Canaveral and in the vicinity of False Cape (see Figure 1), they are absent from the stands sampled in this study. Oak-saw palmetto scrub on Merritt Island lacks scrub palmetto (*Sabal etonia*) and myrtle oak replaces scrub oak (*Quercus inopina*) compared to scrubby flatwoods at Archbold Biological Station on Lake Wales Ridge. Ground cover by *Cladonia* lichens or *Selaginella* is less common in our oak-saw palmetto scrub than in scrub on Lake Wales Ridge (Abrahamson et al. 1984). Currently, data are not available to determine whether oak-saw palmetto scrub historically had a pine overstory. These areas were treeless in 1943 aerial photography (P. Schmalzer, pers. obs.). Oak-saw palmetto scrub is clearly related to scrubby flatwoods vegetation, and the wetter end of the gradient has shrub species characteristic of mesic flatwoods (Abrahamson and Hartnett 1990). Comprehensive vegetation data are available for few scrub areas or types in Florida. Scrub similar to that on Merritt Island occurs on some inland sites; Huck (1987) described scrub oak ridges that graded into saw palmetto flats. Scrubby flatwoods on the southern Lake Wales Ridge occupy positions intermediate between sand pine or rosemary scrub and wetter flatwoods vegetation (Abrahamson et al. 1984).

Vegetation Changes

The postfire response of oak-saw palmetto scrub on Merritt Island is similar to that reported by Abrahamson (1984a, 1984b) for scrubby flatwoods on the

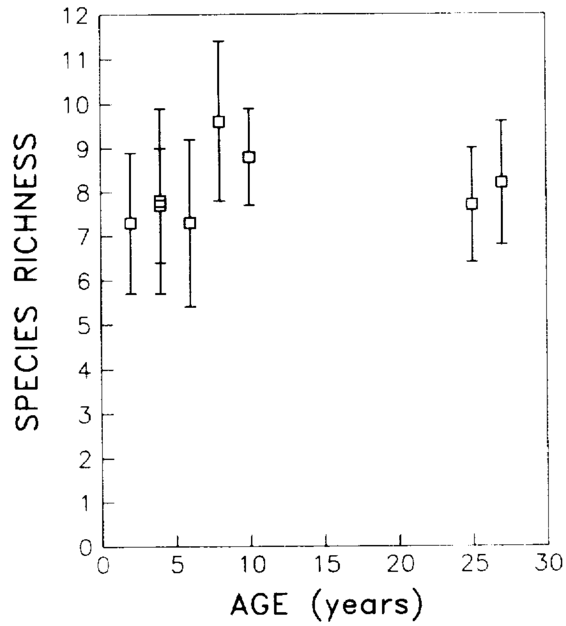

Figure 9. Species richness (mean number of species per transect) in both height layers in scrub stands sampled in 1983 and 1985. Bars indicate 95% confidence intervals.

Lake Wales Ridge and Davison and Bratton (1988) for oak scrub on Cumberland Island, Georgia. Oak-saw palmetto scrub is dominated by species that resprout after fire. Little change in species composition or species richness occurs. Cover in the ground layer (<0.5 m) recovers fairly rapidly. Open spaces do not persist for long, and there is little invasion by new species. Herbaceous species are not a major component of oak-saw palmetto scrub on Merritt Island and show no increased cover that persists to two years postfire. Rosemary scrub, dominated by a seeding species, recovers more slowly and shows an increase in herbaceous species after fire (Johnson and Abrahamson 1990). Dominance by sprouting species is considered an adaptation to repeated fires (Keeley and Zedler 1978, Malanson 1985). However, the shrub species in oak-saw palmetto scrub dominate the understory of sand pine scrub that has a longer (ca. 40 yr) fire cycle. Fire is thought to maintain species diversity in many shrublands (Gill and Groves 1981, Kruger 1983, Christensen 1985). Sprouting species are of importance in California chaparral (Hanes 1971), pocosins (Christensen et al. 1981), *Quercus coccifera* garrigue (Malanson and Trabaud 1987), and other shrublands (Gill and Groves 1981, Kruger 1983).

Our findings concur with those of Abrahamson (1984a, 1984b) in that recovery after fire in oak-saw palmetto scrub is not a successional development in the classical sense, since the species present before the fire are those that come back immediately postfire. Even the oldest scrub stand sampled here showed no invasion by hammock species, only structural changes from continued height and

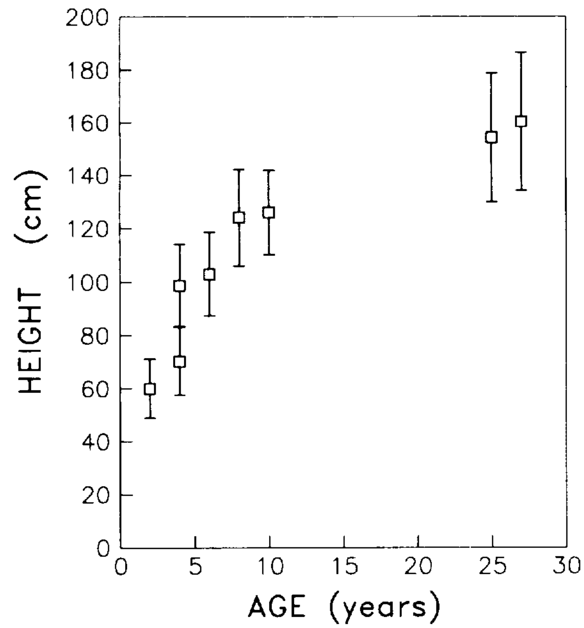

Figure 10. Mean height of vegetation in scrub stands sampled in 1983 and 1985. Bars indicate 95% confidence intervals.

biomass growth. This agrees with the lack of successional (species composition) changes in scrub communities found by Veno (1976), Givens et al. (1984), and Peroni and Abrahamson (1986) but differs from the changes in species composition in longleaf pine/wiregrass communities in the absence of fire (Myers 1985, Myers and White 1987, Daubenmire 1990).

Community Structure

Fire has substantial and long-lasting effects on community structure. The fires that burned Stands 2 and 3 were nearly complete rather than patchy. Oak-saw palmetto scrub will not burn under all conditions; attempts to burn Stand 1 by aerial ignition in the winter of 1983 (a wet winter) failed (P. Schmalzer, pers. obs.) and under other conditions fires are patchy. Total cover in the >0.5 m layer requires about six years to reach 100%; mean height also requires four to six years to exceed one m. Initially, this rate of recovery of canopy cover appears slower than that on Lake Wales Ridge scrubby flatwoods. However, Abrahamson (1984a, 1984b) did not consider cover in height classes; thus, the recovery of scrubby flatwoods to its preburn coverage in two years after fire there is without reference to height classes. Also, that fire at Archbold burned about 30 to 60% of the vegetation along transects, while those on Merritt Island burned nearly 100%. Other fires at Archbold have been nearly complete (Eric Menges, pers. comm.). Rates of height growth for individual species (Abrahamson 1984a, 1984b) seem comparable between the two sites. Height growth is much slower at both of these sites than on Cumberland Island, Georgia where oak sprouts exceeded two m by two years postfire (Davison and Bratton 1988).

These structural changes have implications for the suitability of this habitat for scrub endemic animals, particularly the Florida scrub jay. Scrub jays prefer oak-dominated scrub about 1.5 m in height where open areas (sand or vegetation <15 cm) occur (Breininger 1992). Gopher tortoises, in contrast, occur in higher densities in more recently burned areas (Breininger et al. 1988). At the rates shown here for oak-saw palmetto scrub on Merritt Island, four to six years are required for mean height to reach one m, and height is less than three m at 25 years, although some individual oaks exceed three m at 25 years of age. Open areas are, however, uncommon in undisturbed oak-saw palmetto scrub (see Breininger and Schmalzer 1990) and do not persist long after fire. A mosaic of burned areas providing openings and more mature scrub providing height would be preferable to uniform treatment. Christensen (1985) suggested that it may be important to incorporate variability into management strategies for shrublands; this may well apply to scrub.

Observations here are those of recovery after a single fire. Repeated, frequent fires have the potential to effect changes in community composition not seen after a single fire if root carbohydrate reserves of sprouting species are depleted (Hough 1968; Harrington 1985, 1989).

CONCLUSIONS

1. Composition of oak-saw palmetto scrub vegetation on Merritt Island is closely related to depth to the water table with oaks dominating the drier sites and saw palmetto wetter ones.

2. Scrub vegetation is dominated by shrub species that resprout after fire, resulting in little change in species composition or richness. Dominance shifts after fire to the more rapidly growing species. Scrub resembles other shrublands dominated by sprouting species. Structural changes (total cover, height) continue for many years after fire.

3. Scrub vegetation responses to fire, habitat requirements of the vertebrate species dependent on scrub, and the variability inherent in natural fire regimes need to be considered in developing fire management plans for this vegetation.

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